Voorhees Replacement Hospital

Voorhees, New Jersey

Thesis Proposal

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Structural Option

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Executive Summary

In this proposal for the Voorhees Replacement Hospital, it is determined that the helipad currently located in the parking lot area would be better served if it were located on the building's roof. Doing this will ensure that patients have to wait less time to get the emergency treatment that they need by eliminating any ambulance travel currently required to get the patient from the helipad to the hospital.

An in-depth study will need to be done to find the strength and other requirements for helipads located on the top of buildings. After researching the requirements of helipads a spot will need to be located to put the helipad. Locations close to existing elevator shafts will be explored in order to easily transport any patients from the roof down to the emergency room. The pad will then be designed as a two-way slab in order to support the required loads. If the helipad's supports do not match the gridlines of the building, a transfer beam will be required in order to transfer the loads to the building below.

The building's gravity structural system will be redesigned as a part of this proposal. The gravity system's members will be inspected and their sizes increase for the new loads introduced from the helipad. This will also require a look at the building's foundations in order to ensure they are of adequate size for the new loads.

The building's lateral system will also have to be redesigned for the new seismic loads that the helipad will create. By adding more weight to the building the seismic load will increase. A new seismic analysis will need to be preformed. The values found will be inserted into an ETABS model and the member sizes will be checked for strength requirements.

Building B's lateral system will be changed by replacing moment connections with braced frame connections. This will help stiffen the building in the East – West direction.

The helipad will also require special lighting concerns so that the helicopter can see where it's landing. These new lights will need to be designed and then wired into an existing panel. Since it might be a large distance from the helipad to the panel, a voltage drop calculation will need to be performed.

The helicopter will also create a lot of extra noise on top of the building. An acoustical analysis will need to be performed for the building envelope to ensure that there is not a large amount of noise in the patient areas. If the building's envelope is found to be inadequate for the noise added, a redesign of the façade will be required to ensure a proper decibel reading from inside the room.

Introduction

The Virtua Voorhees Replacement Hospital is located in Voorhees, New Jersey (Latitude: 39.84° Longitude: -74.93°), immediately off Rt. 73. It will be replacing the old Voorhees hospital because of its inability to be renovated. The new hospital will have 9 floors, starting with a Garden Level continuing up through Floor 8. The building is broken up into two main areas, the main bed tower (referred to as Building A, or Northern Building in this report), and a services building (referred to as Building B, or Southern Building in this report). The building is also broken up into 7 smaller zones, for ease of reference in the drawings. Figure 1 shows how the building is split up.

The main bed tower, zones 1-3, is 8 levels and holds 350 individual patient rooms. It is a curved building with a curtain wall facing the majority of the site. This curtain wall allows residents to get an excellent view of the site as well as the wetlands that were protected during construction. The majority of the 8 floors in the main tower have the same floor plan with minor differences.

The services building, which holds zones 4 through 7, is attached to the main bed tower via a thin corridor. The services building houses most of the labs, offices, and surgical rooms needed in the hospital. These services are located between the ground floor and the 5th floor. Above the 5th floor, the building narrows, to match the width of the corridor connecting the bed tower and the services building. Mechanical spaces start on the 6th floor and continue up to the 9th floor. The services building also allows for future growth, with the potential to add more space on top of zone 6.

For this proposal of the Voorhees Replacement Hospital, an existing condition is looked at and a new solution is attempted to be found for it. The proposed structural solution is outlined followed by two minor non-structural solutions. The solution method is introduced showing detailed each step that needs to be taken in order to solve this problem. Tasks are created in order to break the large solution into smaller solutions, and a schedule is created to show the speed in which each task will be accomplished.

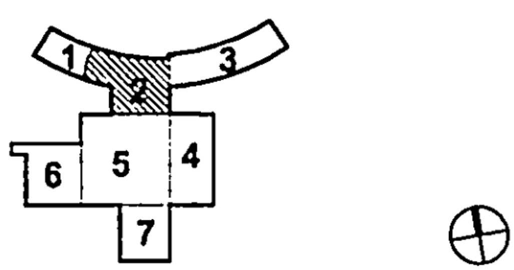


Figure 1 – Key Plan

Structural System Overview

Foundations

The soil for the Voorhees Replacement Hospital is mainly a sandy soil. To prevent these loose soils from liquefaction, stone piers, or geopiers, are required to densify the soil. These geopiers are required to increase the bearing pressure of the soil to 6,000 psi for the soil below all the building's foundations, canopy foundations, and utility structures. For any soil below the site's retaining walls, the bearing pressure is required to be increased to 3,000 psi. The minimum required equivalent coefficient of friction equals 0.36 for sliding resistance across the entire footing bottom area for the retaining walls, and brace frame foundations.

The foundation system is a series of concrete footings either resting on concrete piers or resting on grade. The exterior columns are concrete footings with sizes ranging from 4' x 4' x 1' – 6" to 13' x 13' x 3' – 4" with rebar sizes ranging from #6 - #10 both ways. The columns that rest on concrete piers range in size from 2' – 4" x 2' – 4" to 3' x 4' – 6" with rebar sizes ranging from #9 - #11 for the vertical reinforcement, and #4's or #5's for the ties.

The garden level floor system is constructed, in most places, using a 5" concrete slab on grade, with 6 x 6 – W2.9xW2.9 WWF. In specified spots the size of the concrete slab is increased for specialized equipment, such as refrigerator equipment required for both the kitchen and the dietary section of the hospital. In zones 4 and 5, a grade beam travels along the perimeter.

Floor System

The floor system of the Voorhees hospital is a composite steel/concrete system. In Building A the typical bay sizes are around 30' x 30' or 30' x 10', depending on the area of the building they are located in. In Building B the bay sizes are typically 31' – 4" x 31' – 4" or 31' – 4" x 29' – 4". 3 – ½" light weight concrete sits on top of 3" x 18 Gage composite steel deck. The total thickness of the concrete is 6 – ½" with 6x6-W2.1xW2.1 WWF.

The steel deck is connected to the W-shape beams by ¾" diameter x 5" long shear studs allowing the two systems to work together in composite action. The beams then frame into larger W-shape girders via a single angle connection or a single plate connection. The beams are coped allowing them to connect to the girder's web so that the composite deck can sit on both the beams and the girders. The W-shape girders frame into W-shape columns by either double angle connections, or by moment connections.

Columns

Typical columns for the Voorhees Replacement Hospital are W14's. The gravity columns are much lighter than the lateral columns. This is due to the added lateral force that the lateral columns must take. The columns are spliced every two floors, 4'-0" above the floor with either a bolted column splice or a welded splice. The columns located in zone 6 are designed for future expansion to be built above.

Lateral System

The Voorhees Replacement Hospital uses a combination of braced framing and moment connections for its lateral system. Though, in both buildings the composite floor system and the roof deck acts as a diaphragm to transfer loads to either the braced frames, or the moment connections. In building A the braced frame supports the N-S lateral forces while the moment connections brace the E-W lateral system. The braced system consists of diagonal, square, HSS connected to W shapes. The braced frames are of two different styles, the bracing either frames from corner to corner, or from lower corner to the midpoint of the top beam. The moment frames in the Northern Building support the E-W lateral forces. The moment connections are located at the columns at the perimeter of the building

In Building B a combination of systems is used. In the N-S direction braced frames are used to resist the lateral forces. In the E-W direction, both braced frames, and moment connections resist the loads. The moment connections, again, are typically exterior columns running along the perimeter of the building. The diagonal braces are typically, like in Building A, diagonal HSS's connected to W shapes.

Building A and Building B are separated between zones 2 and 5 with a 1" expansion joint. This expansion joint allows the two building's lateral systems to act separately when forces are applied.

Roof System

The roof system is composed of 3" x 20 Gage steel roof deck topped with a concrete slab, vapor retarder, and insulation system. In certain areas the roof deck must support the green roof. To support the extra 100 psf of added weight from the green roofs, W shapes are added with a short beam to beam span.

Problem Statement

Project Goal: *To relocate the helipad that is currently located in the parking area, to the top of the building and replace moment connections with braced connections.*

The Voorhees Replacement Hospital currently has a helipad located away from the building in the parking area. (Figure 2) For the purpose of this thesis, the helipad will be relocated onto the top of the new building. Also, Building B's lateral system will be altered to eliminate moment connections, replaceing them with braced connections. By altering the lateral system in building B, the building's circulation will need to be looked at.

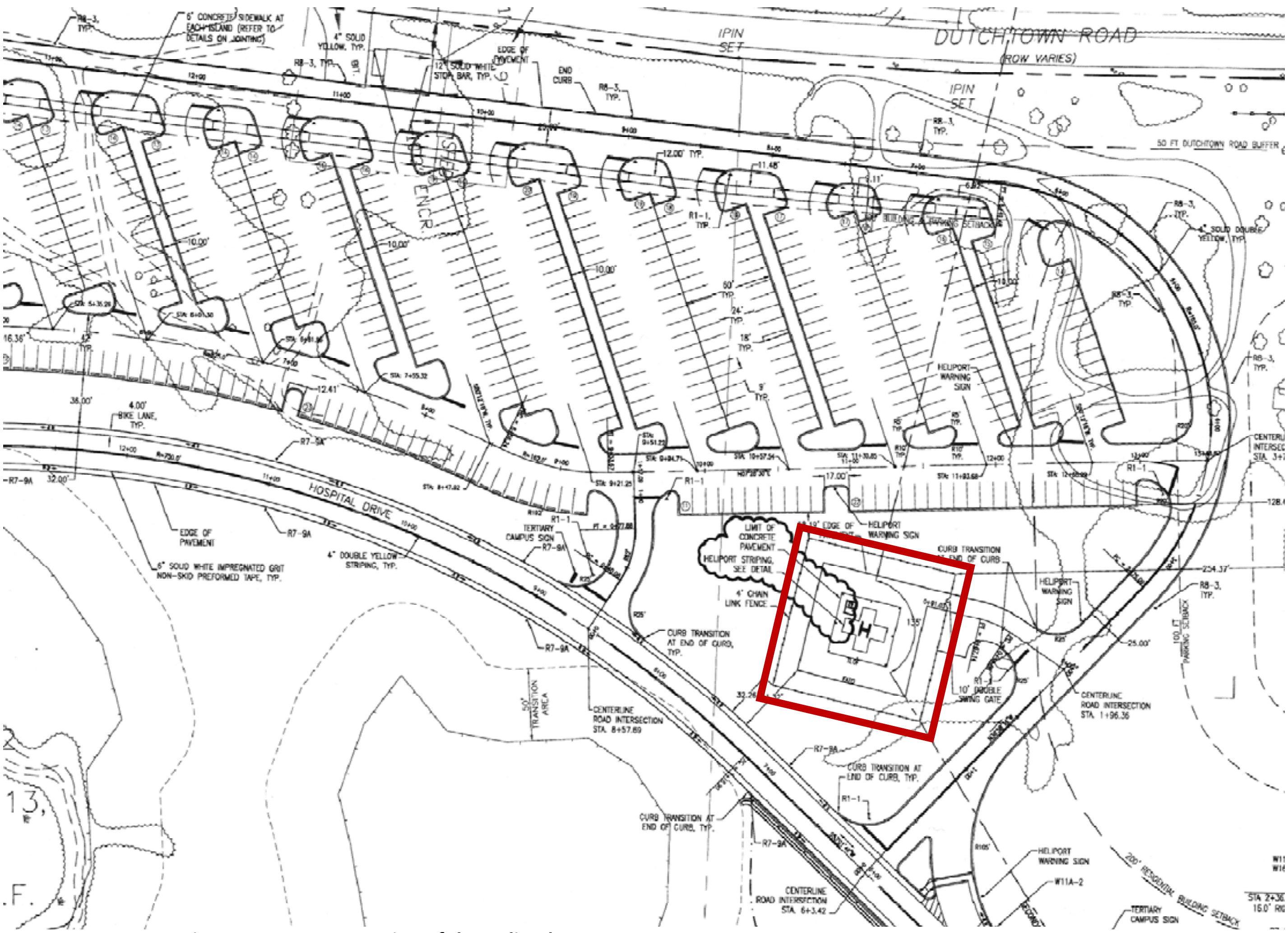


Figure 2 - Current Location of the Helipad

Proposed Solution

Proposal: *To redesign the Voorhees Replacement Hospital to allow for a helipad located on the top of the building, and to eliminate moment connections in Building B.*

An in-depth study will be preformed to find any and all requirements for helipads that are located on top of hospitals and other building types. Because the helicopter will be refilling on the helipad certain requirements may be necessary for spill containment and fire protection. Also, there will be special requirements for fall protection, and other safety concerns that will need to be researched.

After the requirements are found, a design of the helipad will be required. First, a spot located on the roof will need to be found. The ideal spot for the helipad is somewhere located next to an elevator shaft so that the patient can be easily transported from the helipad to the emergency room. After finding a spot the helipad will be created using a concrete pad supported by steel members. The concrete pad will be a two – way concrete slab since the helipad is square. The pad will be supported by steel W shapes that frame down to the building's structural system. If the columns do not line up with the building's grid line, a transfer girder will need to be designed to transfer the loads from the W helipad members to the W columns in the building.

The building's gravity system will need to be redesigned to account for the extra gravity loads introduced from the helipad and the helicopter. The structural system will continue to be composite steel beams with steel columns. Member sizes will be increased so that they are acceptable for the new loads. The current bay sizes will be used throughout the building in order to maintain the proper circulation in the building.

The building's lateral system will also need to be redesigned. It was found in Tech #3 that the seismic forces in the North – South direction controlled over the wind forces. Since the seismic forces are directly related to the building's weight, when the extra weight of the helipad and the helicopter are added the seismic forces will be increased. Therefore the lateral members must be redesigned for the new forces. Also, in Building B the lateral system will be altered in order to eliminate any moment connections. This will help to stiffen the building in the East – West direction. The building's circulation will have to be looked at as a result of this. By adding braced frames there is potential that a wall will be added in a hallway resulting in a circulation problem. If this is found to be the case then potential solutions will be looked at, such as moving the hallway, or using a specialized brace that does not effect the entire bay, such as a 'V' brace.

Solution Method

The helipad will be designed as a two-way slab system. The design of the two-way slab will be based on ACI 318-08 Direct Design Method. Slab thickness and rebar sizes and locations will be determined through these hand calculations. The steel beams and columns will be designed using the 13th Edition of the Steel Construction Manual by the American Institute of Steel Construction. All designs will be performed using LRFD.

Lateral forces will be determined using the methods found in ASCE 7-05. The calculated lateral forces will be input into ETABS. Existing member sizes will also be input into the ETABS model in order to check the capacity of each member. Failing members will be redesigned using the computer program ETABS and hand calculations using the 13th Edition of the Steel Construction Manual.

Breadth Topics

Lighting/Electrical: To design the required helipad lighting requirements and determine wire sizes and lengths for the new lights.

The relocation of a helipad to the roof of the building will require special lights to be added so that the helicopter can see the helipad in the dark. These lighting requirements will be researched, and new lights will be chosen and placed on the new helipad per the requirements. The lights will also need a source of power to ensure that they are always available. Possible sources of power will be researched in the existing plans and new wires will be designed for the lights. A path for the wires will be determined and the voltage drop will be checked to ensure that the new wires are a reasonable length. The wire sizes will be changed if the voltage drop is found to be excessive.

Acoustics: To ensure that the added noise from the helicopter does not increase the noise in any part of the building below the helipad, or within sight of it.

The new Voorhees Hospital uses many methods to make sure that their patients are in a healthy stress-free environment. If noise from a helicopter can be heard in the hospital then all of the work the designers have done to create those friendly, stress-free environments will be lost. Therefore, the building envelope will have to be studied in order to ensure that the noise in the building is not a distraction. The noise levels are likely to increase even though there is already a helipad on site. The current helipad is far away from the building in the parking area, if it is moved to directly on top of the building then noise will increase significantly. If the noise levels are found to be too high in the building, then the building envelope will have to be redesigned in order to reduce the noise levels.

MAE Course – Related Study

The MAE requirement for this project will be fulfilled through the seismic analysis. Methods taught in AE538: Earthquake Design will be used to determine the seismic forces, and design the lateral members accordingly. Additionally, use of the AE597A: Computer Modeling course will be vital when creating an ETABS model of the hospital. ETABS modeling will be used to analyze and design both gravity and lateral members.

Tasks and Tools

Depth

1. Use IBC and ASCE to find any requirements for a helipad located on top of a building
    a. Determine the required loads that a helipad must resist
    b. Determine the required size of a helipad
    c. Determine any special requirements for a helipad
2. Design the helipad
    a. Find a location on the building that is best for a helipad
    b. Design the helipad according to the size and strength requirements found in Part 1
3. Redesign the gravity system
    a. Create an ETABS model of the building's gravity system
    b. Determine the new loads on all of the affected columns
    c. Redesign columns that do not meet strength requirements
4. Redesign the lateral system
    a. Create an ETABS model of the building's lateral system
    b. Determine the new lateral loads on the building
    c. Redesign the lateral system for the new loads
    d. Redesign Building B's lateral system to exclude moment frames

Breadth

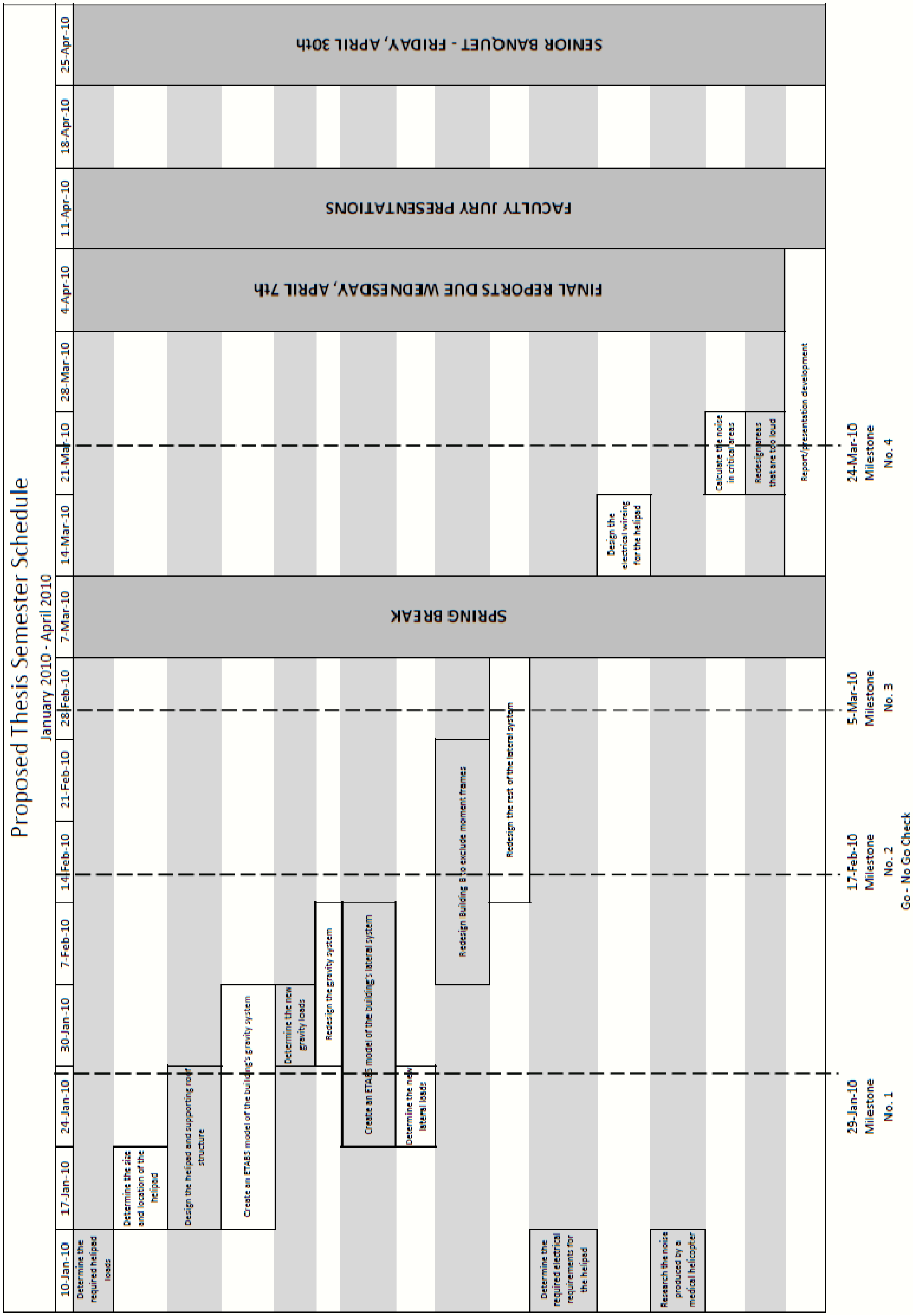
Lighting/Electrical

1. Determine the required lighting/electrical requirements for a helipad
2. Find a panel for lights to wire into and design the wires
    a. Find the Voltage Drop in the wires

Acoustics

1. Research the noise produced by a medical helicopter
2. Calculate the noise in patient's rooms, and other critical areas
3. Redesign areas that do not meet requirements

Schedule


Proposed Thesis Semester Schedule
January 2010 - April 2010
10-Jan-10
17-Jan-10
24-Jan-10
30-Jan-10
7-Feb-10
14-Feb-10
21-Feb-10
28-Feb-10
7-Mar-10
14-Mar-10
21-Mar-10
28-Mar-10
4-Apr-10
11-Apr-10
18-Apr-10
25-Apr-10
Determine the required helipad loads
Determine the size and location of the helipad
Design the helipad and supporting roof structure
Create an ETABS model of the building's gravity system
Determine the new gravity loads
Redesign the gravity system
Create an ETABS model of the building's lateral system
Determine the new lateral loads
Redesign Building B to exclude moment frames
Redesign the rest of the lateral system
Determine the required electrical requirements for the helipad
Design the electrical wireing for the helipad
Research the noise produced by a medical helicopter
Calculate the noise in critical areas
Redesign areas that are too loud
Report/presentation development
SPRING BREAK
FINAL REPORTS DUE WEDNESDAY, APRIL 7th
FACULTY JURY PRESENTATIONS
SENIOR BANQUET - FRIDAY, APRIL 30th
29-Jan-10
Milestone
No. 1
17-Feb-10
Milestone
No. 2
Go - No Go Check
5-Mar-10
Milestone
No. 3
24-Mar-10
Milestone
No. 4

Conclusion

In this proposal it is determined that the helipad might be better used if it were located on top of the building rather than in the parking lot. It will help patients with little time to spare by avoiding an unnecessary ambulance ride from the helicopter to the hospital.

In order to redesign the building for the new helipad located on top of the building, an in-depth study must be done to find the strength and other requirements of helipads. After finding the requirements of helipads, a spot will be located on the roof for it, and it will be designed accordingly. If the helipad supports do not match the grid lines of the building, then a transfer beam will be used in order to transfer the loads to the building below.

The building's structural system will need to be redesigned to take the new loads introduced by the helipad. The gravity system's members will need to be looked at and possibly increased to allow for the new loads that the helipad introduces. This will also require a look at the foundations in order to ensure they are adequate for the new loads.

The lateral system will also have to be redesigned due to the increase seismic load that the helipad will create. Since adding more weight to the building will increase the seismic load, the seismic forces will need to be recalculated and the lateral system checked for these new loads. Any loads that do not pass strength requirements for these new loads will need to be redesigned. Also, in the Southern Building the lateral system will be redesigned. Moment connections will be replaced with braced frame connections.

Since a helipad requires a certain amount of light, new lights and their wire layouts will need to be designed. Since the lights will possibly be far from a circuit breaker, a voltage drop calculation will need to be performed to ensure that the wires are of adequate size.

Locating a helicopter closer to the building will also create possible noise problems. Since a helicopter creates a large amount of noise the acoustics of the building envelope will need to be studied in order to ensure the patients are not bothered by the helicopter. If any of building's envelope is found to be inadequate for the noise added, a redesign of the façade will be required to ensure a proper decibel reading inside the room.